CAL POLY CHOCOLATES

A Senior Project submitted

In Partial Fulfillment

of the Requirements for the Degree of

Bachelor of Science in Industrial Engineering

the Faculty of California Polytechnic State University,

San Luis Obispo

by

Jason Ferrel and Taylor Fitzpatrick

June 2013

Graded by:______________ Date of Submission__________________________

Checked by:_____________ Approved by:_____________________________

ABSTRACT

CAL POLY CHOCOLATES

Jason Ferrel and Taylor Fitzpatrick

Our design for this project began with building a strong understanding of the current production process. A meeting with the manager, Anna Nakayama, provided a detailed overview of the entire process and outlined some areas of concern. In addition, she provided us with access to critical data such as standard operating procedures and inventory spreadsheets. From there, time studies were conducted for each of the 8 types of chocolate. These time studies helped identify three main issues facing Cal Poly Chocolates. The first issue is in the packaging area of production. The process is entirely manual and has become a large bottleneck. Secondly, there is a need for a reordering system due to packaging supplies frequently being unavailable. And lastly, Cal Poly Chocolates recently faced the challenge of changing facilities and they have yet to find an efficient layout to optimize their process flow.

In an attempt to eliminate the bottleneck in production, research into a packaging machine was conducted. From there, the total cost of ownership was calculated as well as a return on investment to determine if the purchase was feasible. We discovered the machine will dramatically cut the packaging process times and provide a greater production capacity. To solve the issue of unavailable material, three different reorder systems were developed. There was a need for three different systems due to the variation in demand and order sizes. Assuming the employees are well trained and the demand is monitored correctly, these systems should solve Cal Poly Chocolate's stockout issues. Finally, to aid Cal Poly Chocolates in their facility change we developed a proposed layout that saved thirty feet in excess travel distance.

ACKNOWLEDGMENTS

We would like to thank Anna Nakayama for allowing us to visit the Cal Poly Chocolates facility, and for her cooperation throughout the duration of the project.

Table of Contents

LIST OF TABLES

Table

LIST OF FIGURES

Figure

I. Introduction

Cal Poly Chocolates was created 13 years ago as a course for Food Science and Nutrition students to get hands on experience in food production. It is located on campus at California Polytechnic State University, San Luis Obispo in building 24 room 106, behind Campus Market. Between 4 and 8 students take this course and help run the university's small business. In addition, 4 other students are paid employees.

Typically, two of the paid employees come in every Friday at 8am and begin setting up for that day's production. Then from 11am to as late as 6pm, the rest of the students join them to make the product. During these hours they produce 8 different types of chocolates including peanut butter crunch bars, butterscotch s'mores and chocolate-covered macadamia nuts. The students package about 900 chocolate bars every week all of which are done by hand. The chocolates are then sold on campus and at the Cal Poly Downtown-Gift Shop, as well as Spencer's Fresh Market.

Although Cal Poly Chocolates provides a great learning experience for students, it has failed to succeed as a business. The company has remained stagnant over the years and has failed to improve their efficiency and profitability. The reasons for stagnation are many, but in the area of production their main needs for improvement are in packaging. The process is entirely manual and packaging supplies are frequently unavailable. In addition to the need for improvement, Cal Poly Chocolates faces the challenge of changing facilities. The focus of this report will be on solving the following problems:

- Process improvements
    - Reducing the bottleneck of the packaging process
- Inventory Management

- Developing an inventory theory to prevent stock outs
- Facility Design
    - Optimizing process flow and reducing throughput

Cal Poly Chocolates has potential to improve their company. The weak points in their manufacturing process are packaging and packaging inventory. Packaging by hand takes a long time and is not very efficient. By incorporating a flow wrapper machine in their process they will be able to save money and create better products. However, for this to truly be optimal they need to improve their inventory management with their packaging supplies. They can possibly achieve this through operation research methods. With these changes Cal Poly Chocolates will be able to improve their profitability and become a more successful company.

This report will begin with a background which includes a literature review. It will then move into the body which is divided into the three main problems discussed above. Each section will discuss the design, methodology, and results. The report will then end with concluding remarks.

II. Background

Cal Poly Chocolates is the only university based chocolate production course that uses exclusively organic and Fair Trade Certified™ chocolate. They only operate one day a week, Friday. Their hours of operation are from 8am-5pm with some variability based on the demand for that day. They currently have 4 employees in addition to the 4 to 8 students enrolled in the course. Cal Poly Chocolates produces eight different chocolate products for the San Luis Obispo area. Each product goes through different processes but they all end up needing packaging. Packaging is a bottleneck process for Cal Poly Chocolates.

Cal Poly Chocolates packages every product by hand and requires many workers to get the work done. All the different types of chocolate bars are packaged the same way. The peanut butter cups, cashew caramels, s'mores, and chocolate covered macadamia nuts each require a different packaging process. The variety of packaging makes the packaging process more complicated. Different materials are used for each process and when they run out of the packaging materials they can't package their chocolate products. Packaging costs account for a substantial portion of a product's manufactured cost and so it is desirable to minimize these costs (1). Labor costs increase when they do not have the supplies they need for packaging. They also run into stock outs which influence production and thus sales. Many products wait in the packaging area for a shipment of foil wrappers. Our project is to help improve the packaging system and inventory issues.

There are reasons why food and other products go through a packaging process. Almost everything you purchase from food to electronics has gone through a packaging process before it goes out to retail stores. The most common function of packaging is for the protection of the product. The most common type of protection is used to guard against contamination by microbes or against the loss of important components (3). Food is also packaged to prevent contamination and to preserve the taste. Packaging can increase the food's shelf life. For Cal Poly Chocolates packaging is used to protect the product from outside microbes and dirt. Throughout the chocolate making process employees are required to wear gloves at all times to prevent contamination of the chocolate. Therefore it is important that the products get packaged well to prevent any contamination issues.

Packaging also provides communication with the consumer by using printed words and images. Since packages are the "face" of the product that the consumer will see, usually while trying to decide which of several similar items to choose, the marketing impact of packaging has always been of the utmost importance (3). Most products must include information on their labels like an accurate list of contents or ingredients. As you can see in Figure 1, Cal Poly packages each product differently and uses different colors to tell them apart. Each label has the appropriate ingredient and nutritional value information on it plus the overall design makes consumers want to buy their products.

http://www.behance.net/gallery/Cal-Poly-Chocolates/4224431

Figure 1 : Cal Poly Chocolate's eight different products

Another key aspect of packaging is user friendliness. Packing is often blamed for a high level of consumer frustration in gaining access to products, but nearly all products require some form of packaging (3). A broad range of products could not exist without packaging. For example, Cal Poly Chocolates must place their chocolate covered macadamia nuts into a tin can to keep them contained. User friendliness often leads to integration of packaging into the product process. Integrating the packaging design into the product's manufacturing system is sometimes hard for designers and engineers. A beautiful and useful package that cannot be produced quickly and cheaply will be unlikely to find its way to the market (3). Integration of packaging into the product process is very important, however for Cal Poly Chocolates this step requires the most time.

Currently, Cal Poly Chocolates isn't replenishing their packaging inventory soon enough to avoid shortages. There are many options for management of inventory. One set of methods is from the techniques of scientific inventory management, a subsection of Operations Research that is concerned with the design of inventory systems to minimize costs. Scientific Inventory Management includes the following steps (6):

1. Formulate a mathematical model describing the behavior of the inventory system.
2. Seek an optimal inventory policy.
3. Use a computerized information system to maintain and record inventory levels.
4. Apply the optimal inventory policy to signal reorders and their quantities.

The mathematical inventory models can be divided into two categories based on the predictability of demand. These are deterministic and stochastic models. In the case where the demand is known, a deterministic model is used. However, if there is uncertainty in the demand a stochastic model is the better choice (6).

Due to the variability, stochastic inventory models are often viewed as continuous inventory systems. "Thus, the inventory level is monitored on a continuous basis so that a new order can be placed as soon as the inventory level drops to the reorder point (6)." The reorder point *R* is a predetermined level of inventory. Once inventory reaches this level an order is placed. This is one of the two critical numbers that are calculated in an inventory system (10). The other is the order quantity *Q*, also known as the economic order quantity (EOQ) in deterministic models. These two critical numbers define the stochastic continuous-review inventory policy:

> "Inventory Policy: Whenever the inventory level of the product drops to R units, place an order for Q more units to replenish the inventory (6)."

To calculate Q, four variables need to be defined: average demand d, ordering cost k, holding cost h, and shortage cost p. Ordering cost is fixed and is incurred for each order.

Holding cost is the cost of keeping one unit of inventory and shortage costs are all of the costs that are associated with a stock out.

$$Q = \sqrt{\frac{2dk}{h}}\sqrt{\frac{(p+h)}{p}}$$

To determine the reorder point *R* in a stochastic model, a distribution for the demand must be found. Assuming a normal distribution, the reorder point can be calculated from the average demand μ, the standard deviation σ, and the level of service *L*. The level of service is the desired probability of a stock out occurring. This is something management usually decides. This level of service is then converted to a value K_{1-L} using based on a distribution table (6).

$$R=\mu+K_{1-L}\sigma$$

Another possible inventory solution is a two-bin system. This is the traditional method of implementing a continuous-review inventory system. “The two-bin system is exactly that, a system that requires two storage containers. The containers will each hold a predetermined quantity of the same material. The quantities may be the same, or one may hold a larger quantity than the other (10).” At the bottom of the bin is a reorder card with instruction to place an order at a defined quantity. Material is drawn from only one bin. Once that bin is empty the reorder card is reached and an order is placed. Material is then drawn from the second bin while awaiting the incoming order. When the order arrives it is placed in the empty bin and the cycle repeats. A small amount of training is necessary, but it is straightforward. “The two-bin system is easy to implement and maintain, and it is typically just as effective as any complex computer driven system used to reorder parts” (10).

In order to cut process time and costs, one option for Cal Poly Chocolates is to automating their packaging system. As sales increase they struggle getting the necessary products into the stores. They were looking into purchasing a bar wrapping machine, however the cost is high. The current packaging for the chocolate bars is the traditional foil wrapper and paper label. If Cal Poly Chocolates were to invest in a bar wrapping machine the benefits would be seen in reduced unit costs, consistent high quality, and increased production standby capacity (2). A semi-automated machine requires a worker to place the bars in the machine and remove the finished product. This could cut the number of employees they would need and dramatically cut packaging time or increase capacity. Today the larger half of the factory operations has actually been semi-automated rather than fully automated because the worker-machine combination is often the most efficient and effective in involved tasks (2).

A Swiss chocolate producer Chocolats Halba in 2004 installed a new robotic feeding and wrapping system into their factory. Like Cal Poly Chocolates, Chocolats Halba packaged their chocolates by hand. "The use of robots certainly makes sense where speed is concerned, but it is difficult to depreciate the investment over a reasonable period," according to Bernard Fenner, account manager for Sigpack Systems (15). By installing a robotic system in their factory it provided Chocolats Halba with many benefits. The automation performs exactly as required which often reduces waste and increases yield from the input materials (16). Automation performs reliably over many hours and does not suffer from lapses in concentration or tiredness again providing reliable output (16). Automation eliminates a lot of human error that can result in packaging defects when done by hand. Cal Poly Chocolates has the potential to use automation in their chocolate production, especially for their packaging process.

In order to decide the right equipment to purchase for packaging, Cal Poly Chocolates will need

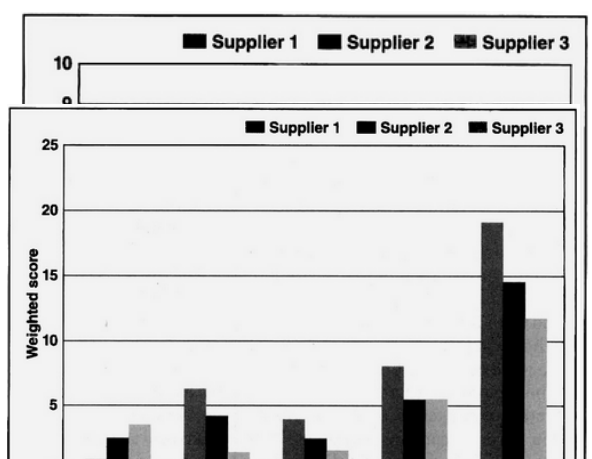


Figure 2: Comparison of the values assigned to each category. (11)

to use a total cost of ownership (TCO) approach to optimize the value of the machine. Undertaking a TCO analysis involves two general steps: gathering raw data on the offerings of different suppliers, including price, reliability, expected lifetime and customer support; and then assigning a weight to each aspect of the equipment, according to its value and importance to the company's particular situation (11). In Figure 2 and 3, on the next page, a TCO analysis example was graphed (11). In Figure 2 the TCO model first compares the value that each supplier offers in different categories. In the graph the price is graphed inversely for value, so a higher cost equals a lower value. From Figure 2, Figure 3 is then created. Figure 3 is developed after assigning weights to the values, according to the company preferences. The weights are then multiplied by the raw values, the total TCO score is calculated by adding the four categories for each supplier. In order to complete TCO analysis for Cal Poly Chocolates, they must determine what is important to them. They need to rate each category on importance and follow the TCO steps to decide what flow wrapper will work best for them.

Cal Poly Chocolates biggest concern right now is saving money. Therefore, a cost benefit analysis is necessary to determine the best solution for their processes. "Not only do they have to prevent failures, but also selecting the best among alternative projects and manage them simultaneously to get their desirable results is vital to make them sustainable in such a competitive environment (13)." Before a decision is made Cal Poly Chocolates, will want to ensure they are implementing the best possible alternative for their company. This could potentially be a large financial investment and a cost benefit analysis will provide them with evidence that they are making the correct economical choice. The following is a list of steps for conducting a cost benefit analysis (12):

1. List alternative projects/programs.

2. List stakeholders.
3. Select measurement(s) and measure all cost/benefit elements.
4. Predict outcome of cost and benefits over relevant time period.
5. Convert all costs and benefits into a common currency.
6. Apply discount rate.
7. Calculate net present value of project options.
8. Perform sensitivity analysis.
9. Adopt recommended choice

Arguable the most difficult component of a cost benefit analysis is “vesting monetary values in intangible elements, such as human life, time lost, and environmental factors (14).” Tangible values are often easy to calculate or find based on competitive markets, but intangibles are difficult to quantify and often vary from person to person. Therefore, it is important to remain unbiased and receive input from multiple sources and use factual evidence to back up these values.

Once everything has been quantified into a monetary value the next steps consist of a transformation of total costs and benefits into a temporal dimension and the introduction of a decision rule (14). Net present value (NPV) can be used to add a temporal dimension. NPV reduces all of the present costs and benefits to an exclusive present value. It is estimated by summing the net benefits present value (NBPV) from year one to N and subtracting the invested cost at N=0. If there are discount rates they are factored into the NBPV. The equation is as follows:

$$NPV=N=1N(NBPV) - I_0$$

NPV values provide the decision rule. Any positive values are feasible and when comparing alternatives the most positive value is the best economic alternative. Although cost benefit analysis are a good analytical method, the final decision must take into account other factors such as social and environmental (14).

III. Packaging

Design

A week after starting this project, Cal Poly Chocolates purchased a depositor. A depositor is a machine that pours chocolate into chocolate bar molds. The molds hold five chocolate bars each. Before the purchase of this machine, chocolate was poured by hand into each mold. This process was the largest bottleneck in the chocolate bar making process. Pouring chocolate by hand took hours to complete and often caused a delay on some orders. Once the depositor was installed the chocolate bar making process time was reduced dramatically. Now a worker can pour 900 bars in less than 40 minutes. With the installment of the depositor the biggest bottleneck was reduced. However, another bottleneck appeared in the process. Since more chocolate bars were being created a bottleneck started to form at packaging. Packaging is done by hand. The manager was looking into purchasing a packaging machine to improve the packaging process. The packaging machine she wanted to purchase was the PAC FW-400F flow wrapper. This machine can wrap up to 120 bars per minute. Installing this flow wrapper in the production line will reduce the time needed to package chocolate bars. The only issue is that a machine, like the flow wrapper costs over $30,000, which a small company like Cal Poly Chocolates is a lot of money. As part of our project we looked into the feasibility of purchasing a packaging machine.

Method

Purchasing a packaging machine will greatly reduce the new bottleneck in the chocolate bar making process. The cost, however, is a concern for Cal Poly Chocolates. Using total cost of ownership calculations and benefit-cost analysis we were able to determine whether they should invest in this machine.

Total cost of analysis was completed first to get a better understanding of the needs of Cal Poly Chocolates. The most important factors for finding a flow wrapper were price, capacity, and process time. The manager rated each category based on wrapping by hand or machine. Table 1 to the right shows the values she gave to each category.

	By Hand	With A Machine
Price	9	4
Capacity	5	8
Process Time	3	10

Table 1: Values the manager gave to each category.

With these values, we graphed each category to see the differences between packaging by hand or by machine. This graph is shown in Figure 4. Then we placed a weight on each category. This weight was decided by the manager and the values are shown in Table 2.

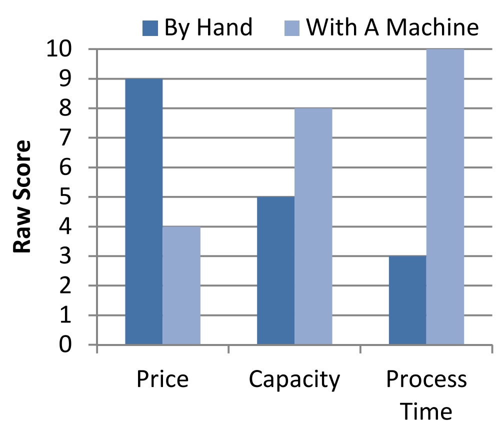


Figure 4: Graphed values from Table 1

Category	Weight
Price	80%
Capacity	40%

Table 2: Manager assigned weights to each category.

The graph of these weighted scores is shown in Figure 5. As you can see there is not a large difference

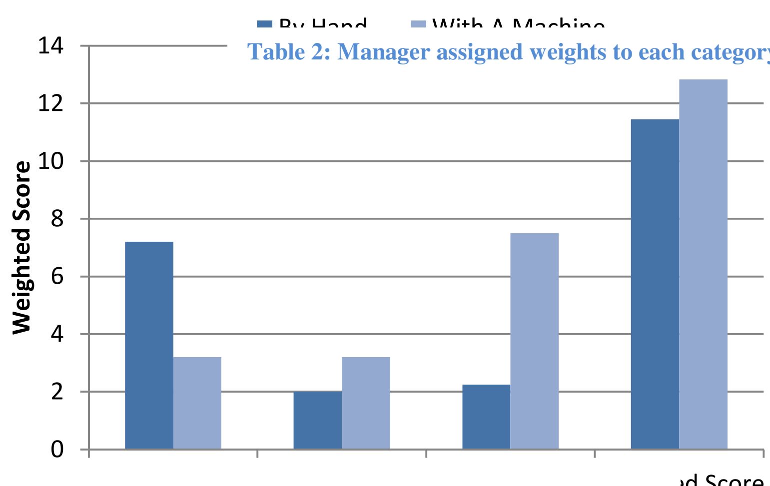


Figure 5: Results from the weighted categories

between packaging by hand compared to packaging by machine. This is because packaging by hand costs less than buying a new machine for the price category. The opposite occurs in the process time category which results in having the weighted scores being close to each other.

Since we were not able to conclude that buying a machine is feasible we completed a return on investment (ROI) analysis. The analysis is for the next three years if a machine is purchased in year zero. The cash flow and ROI statement is shown in Table 3 below. It can also be found in Appendix A.

Cash flow and ROI Statement				
BENEFIT DRIVERS	**YEAR**			
	0	**1**	**2**	**3**
Greater margin driven by higher production capacity		**$14,500**	**$14,500**	**$14,500**
Improved cycle time benefits:				
Reduced labor cost due to less running time		**2,400**	**2,400**	**2,400**
Improved quality benefits:				
Fewer defects, resulting in less rework		**600**	**600**	**600**
Improved customer benefits				
New customer orders		**2,250**	**4,500**	**6,750**
Total annual benefits		*$19,750*	*$22,000*	*$24,250*
Implementation filter		**90%**	**95%**	**100%**
Total benefits realized		*$17,775*	*$20,900*	*$24,250*

Table 3: Cash flow and return on investment statement for the purchase of a flow wrapper.

To determine the values in the table we looked into how much Cal Poly Chocolates makes off their products in a school quarter. For example, The Cal Poly Bookstore and Madonna Inn both order a certain amount twice a quarter, whereas Campus Market places orders four times throughout the quarter. Each order size is different per store, Campus Market orders 200 of each kind of chocolate bar whereas Madonna Inn orders 10 to 20 of every type of chocolate bar. With the chocolate demand given to us we were able to calculate the profit of that school quarter. The quarter we observed sold $19,298 of product. By subtracting the cost of materials and labor we get a profit of $13,205 for that quarter. By the end of this year they expect to bring in $40,000 to $50,000 from their regular customers alone. They also fill special orders when there is available capacity.

Installing a flow wrapper in the production line will increase production capacity. This would allow workers to produce more product which leads to higher returns. To calculate this profit margin we calculated how much time is saved with the flow wrapper in the production line. There is an average savings of 1.08 production hours per day. We then looked into what process can be completed in that time frame. In an hour a worker can make 100 butterscotch s'mores bars and another worker can make 450 chocolate bars. Subtracting the cost of materials and labor from the profit of those 550 products obtains an additional profit of $480 per production day. In a given year there are 30 production days. So over a year the profit from producing these extra products would be $14,500. This value can increase in year two but to be on the safe side we kept the margin for each year the same.

With the implementation of the flow wrapper there are some benefits that will increase revenue. The first is an improvement in cycle time. With a shorter cycle time less labor is needed and therefore labor cost can be decreased. With a flow wrapper installed only two workers are needed to operate rather than having four workers wrap by hand. By cutting the number of workers needed Cal Poly Chocolates can see a savings of $2,400 a year on labor.

Defects also occur during packaging of the chocolate products. The foil used to wrap the chocolate bars is thin and often tears when folding. About 2%, or 18 out of the 900 bars produced must be rewrapped. With a flow wrapper the defect rate would be reduced to 0.25% saving $600 per year.

With the increase in capacity and decrease of defects Cal Poly Chocolates will be able to gain more customers. They would be able to process more orders in a production day, allowing for more potential customers, without the addition of labor. They would start selling their products to markets or stores outside of campus. An example would be Spencer's Market who purchases $2,250 from Cal Poly Chocolates each year. Using this value as a guide for companies outside of campus we can assume orders around this size will be ordered. As the years go by more customers will purchase Cal Poly Chocolate products. So the profit from new customer orders will increase each year.

Finally, we placed an implementation filter for each year. For the first year they would not be able to utilize the machine completely because they would still be adjusting to the new machinery. By year three the machine should be fully implemented and producing at full capacity. With the completed Table 3 we calculated the return on the investment and the payback period.

Results

Using Table 3 in the above method section we were able to determine the net present value, return on investment, and the payback period for the purchase of a packaging machine. Table 4 on the following page shows the results from these calculations:

ROI measures		Year 1	Year 2	Year 3
Cumulative benefit flow	*(38,329)*	*(20,554)*	*346*	*24,596*
Net present value	*$8,875*			
Return on investment		*46%*	*55%*	*63%*
Payback (in years)	*1.98*			

Table 4: Return on investment, net present value, and payback all calculated from Table 3.

The net present value (NPV) compares the present value of the money invested today with the value of that money in the future. Before calculating NPV a rate of return is set. The rate of return for this purchase was 15%. Using excel we obtained a NPV of $8,875. This value is positive so the investment would add value to Cal Poly Chocolates. In addition to the NPV we calculated the return on investment for each year. This is obtained by dividing each year's net cash flow by the cost of the machine. By year three we achieved a return on investment of 63%. A 63% return on an investment means that the $38,329 investment would return $24,147.27 in that year. This positive return is another reason why Cal Poly Chocolates should invest in a packaging machine. With a high percentage of return on investment Cal Poly Chocolates will be able to payback the investment in 1.98 years. This quick turnover would justify the purchase.

We did think of some alternatives for Cal Poly Chocolates that they can implement before deciding to invest in a packaging machine. We suggest creating fixtures that will speed up the packaging process. Placing fixtures in the packaging process would cut packaging time. However, this quick fix will not provide the process time improvement Cal Poly Chocolates is searching for. That improvement can only be achieved through the purchase of a packaging machine.

IV. Inventory Reordering System

Design

The second problem we addressed is their inventory system. Currently, Cal Poly Chocolates has no inventory reordering system. The employees simply wait until they notice there is a limited amount of inventory then place the order. Too often this order is placed late and a stock out occurs. An easy solution to this problem is implementing a two-bin system, which was discussed previously in the literature review. "The two-bin system is exactly that, a system that requires two storage containers. The containers will each hold a predetermined quantity of the same material. The quantities may be the same, or one may hold a larger quantity than the other (10).” Material will be pulled from one of the bins. Once that bin is empty an order is placed and material is pulled from the second bin and the process repeats itself. At the bottom of each bin lies a reorder card, similar to the one in Figure 6, which contains all of the necessary information to place these orders.

Description				Card 1 of 2	
				Location	
Qty		Lead Time		Order Date	
Supplier				Due Date	

Figure 6: Reorder card

This system appears to be the best for Cal Poly Chocolates due to their raw materials being very inexpensive and easy to store. Its simplicity also makes sense because it would be very difficult to develop a reliable distribution for their demand. There would be no need to rely on a computer to decide when to order. Instead, they would simply rely on their employees eyes. A small investment of purchasing small totes for the different material storages would be necessary, but over time this would save money that they have previously been losing due to stock outs.

Although this system works best for a majority of their inventory, it is not an effective reordering system for all of it. Some of the raw materials have a minimum order quantity that is far too large for a two-bin system to work. For these cases, each raw material was looked at individually and both a reorder point and a reorder quantity were calculated. These values are discussed in the results section.

Method

For this system, only one variable needs to be determined, the reorder quantity. This quantity is also the amount of inventory in each bin when they are full. To find this quantity we took the following steps.

We began with three data sheets that were provided by Cal Poly Chocolates: Standard Operating Procedures, Product Demand Summary, and an Inventory Spreadsheet. The inventory and demand spreadsheets can be found in Appendix C, in Table 7 and Table 8. Taking the information from the standard operating procedures, we were able to create a bill of materials for each of the eight products. Next, we calculated the annual demand for each finished product. This was calculated by multiplying the demand per quarter by 3. This assumes that Cal Poly Chocolates does not produce during the summer quarter. Then, by taking the annual demand for each product and using the Bill of materials we were able determine the demand for all of the raw material. Table 5 on the following page shows the Bill of Materials for the Milk Chocolate Bar with the annual demand for each raw material. The tables for the other products can be found in Appendix C, Table 9 to Table 15.

MILK BARS				
Ingredient	**Unit of Measure**	**Quantity**	**Notes**	**Annual Demand**
Milk Bar (43g)	each	300		5085
Milk Label	each	300		5085
Foil	each	300		5085
Glue			too small	0
Cocoa Butter	scoops	4		67.8
Milk Chocolate	lbs	30		508.5

Table 5: Milk bar bill of material

Using the lead times provided by the inventory spreadsheet, we were able to calculate the demand during the lead time (DDLT). This was calculated using the following equation:

$$\text{DDLT} = \text{Annual Demand (demand/year)} \div 30 \text{ Weeks (weeks)} \times \text{Lead Time (weeks)}$$

With ten weeks in a quarter and three quarters per year, we estimated there to be thirty weeks of production per year. Thirty weeks was used to convert the annual demand to weekly demand. Then by multiplying the weekly demand by the lead time, we arrived at the DDLT.

In an ideal system where there is no variability in demand and any order size can be made we would use this value as our reorder point, however this is not the case. Due to both minimum order quantities and order sizes, we rounded up the values of the DDLT to the next multiple of a typical order. For example, if the DDLT is 240 units and a typical order is 75 units, the reorder quantity would be 300. Rounding up also helps to account for variability in the demand. This would typically be calculated using the standard deviation of the DDLT, but due to the lack of statistical data this was not possible. Many of these values are very conservative, but can be justified because the inventory is very inexpensive when compared to the cost of a stock out.

In addition to the inventory that fit a two-bin reorder system, there are fourteen other raw materials that currently lack a reorder system. Due to the large minimum order quantities, it does not make sense to use a two-bin reorder system for these. Eight of the fourteen materials, use such small quantities at a time that there is no issue with the current system of simply eyeballing the inventory and placing an order when it gets low. These eight raw materials are ingredients such as peanut flour, marshmallow fluff, and peppermint oil.

The remaining six raw materials are milk chocolate, dark chocolate, caramel cashew boxes, macadamia nut tins, staples, and glue sticks. These have similar issues to the raw material that was discussed above in that they have very large minimum order quantities. However, these raw materials are used much more frequently and in larger quantities. To solve this problem we decided to use a more typical reorder system. This reorder system uses a reorder point in addition to a reorder quantity. Once the inventory reaches the reorder point an order is placed. For simplicity, we recommend Cal Poly Chocolates place a card on each of these inventory storage containers that informs the workers to place an order once they see the inventory has reached a certain level.

The reorder quantities were easily calculated because they are just the minimum order quantities. The reorder points were calculated the same way that the reorder quantities were calculated in the two-bin system. This is because in the two-bin system the reorder quantity and the reorder point are the same.

Results

Table 6 on the following page shows the summarized results from the Inventory calculations. As discussed earlier, three types of inventory systems have been developed. The orange-colored cells represent the reorder quantities for a two-bin reorder system. The green-colored cells represent the reorder quantities and the reorder points for the continuous review system. The blue-colored cells represent the order quantities for the materials that do not require a structured reorder system.

To implement this new system a small investment in totes is needed. These totes cost about $40 for a set of 3 (17). Two totes will be needed for each material that uses the two-bin system. Except for the chocolate, one tote will be needed for the material that uses the continuous review system. This adds up to a total of 38 totes (39 using orders of 3) with a one-time cost of $520.

For the most part, the results for the inventory reorder system calculations were what we expected. However, the large order quantities did provide some unexpected challenges and forced us to deviate from our initial plan. Ideally, the design should have looked into this possibility as well as other possible inventory systems rather than focusing only on the two-bin reorder system.

Item	Order Quantity	ROP
RAW MATERIALS		
Milk Chocolate	1 pallet	12 bags
Dark Chocolate	1 pallet	12 bags
Cashews	30 lb case	
Macadamia Nuts	25 lb case	
Peanut Flour	50 lbs	
Powdered Sugar	50 lbs	
Graham Crackers	1 pk	
Vanilla	1 qt	
Cal Poly 127	1 barrel	
SG-3L Glaze	3 gallons	
Marshmallow Fluff	1 case	
Crisped Rice	10 oz boz	
Peppermint Oil		
PACKAGING MATERIAL		
Boxes	5000	300
Tins	1000	75
Inserts	500	
Foam	1000	
Glue Sticks	1 pack	5
Staples	1 box	250
Milk Labels	600	
Dark Labels	600	
Peanut Butter Crunch Labels	600	
Peppermint Crunch Labels	600	
Cashew Caramel Label	100	
Peanut Butter Cup Label	100	
Smores Labels	100	
Mac Nut Labels	100	
CP Sticker Sheets	400	
Foil	2000	
Gift Bags	250	
Shrink Bands	250	

Table 6: Reorder Quantities

Although this solution should provide Cal Poly Chocolates with a reliable inventory reorder system, possible problems could arise if it is not implemented and monitored correctly. All employees should be informed and trained in the new policy otherwise the previous issues will continue to occur. Also, the demand needs to be monitored. If there are large changes in demand the reorder quantities and points will need to be recalculated. Assuming the employees are well trained and the demand is monitored correctly, this system should solve Cal Poly Chocolate's stock out issues.

V. Facility Layout

Design

Lastly, to see how the layout of machines and tables affect the chocolate making process we analyzed the facility layout. We collected the dimensions of every machine and workspace in the facility. The current layout is shown in Figure 7. There were many constraints on the location of certain machines. The depositor needs air and water and the facility only has one hookup for each. The air and water hookups are located on the right wall in the diagram shown. A machine that produces the cashew caramels also uses the air hookup as well as electricity. We also had to consider the location of power outlets in the facility because every machine requires one. Finally the current packaging area is actually in a nook where the floor is higher than the

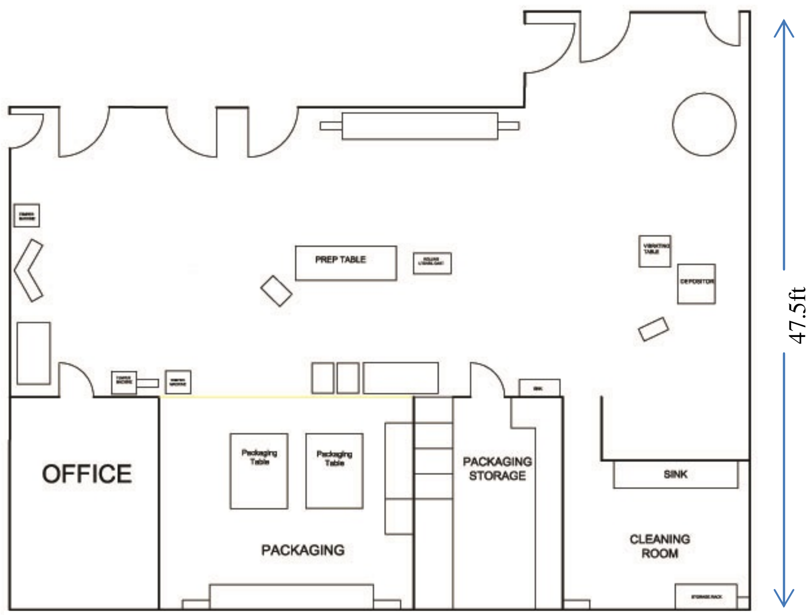


Figure 7: Current facility layout. A larger image can be found in Appendix B

production floor by a few inches. We had to consider whether to use the space for any machines or keep it as the packaging area.

Method

Before the beginning of this year Cal Poly Chocolates was sharing a facility with another Cal Poly food production. The facility was quite large; however Cal Poly Chocolates only used a small portion of it. They have recently been moved into the old meat processing facility. This facility is a lot smaller and they have it all to themselves for the time being. We created a layout in AutoCAD to represent the layout of machinery in the facility. We used AutoCAD to create a string diagram and flow operations chart for the current and proposed layouts.

The first step in analyzing the facility is to see the flow throughout the facility. Figure 8 shows a string diagram of the movement of chocolate during the chocolate bar making process. The chocolate pieces enter through the door at the top right of Figure 8 and are place on the prep table to be placed in large tubs. These tubs then are transported to the temper machines where the chocolate begins to melt. After two to three hours the chocolate is then moved to the prep table to be stirred and measured for

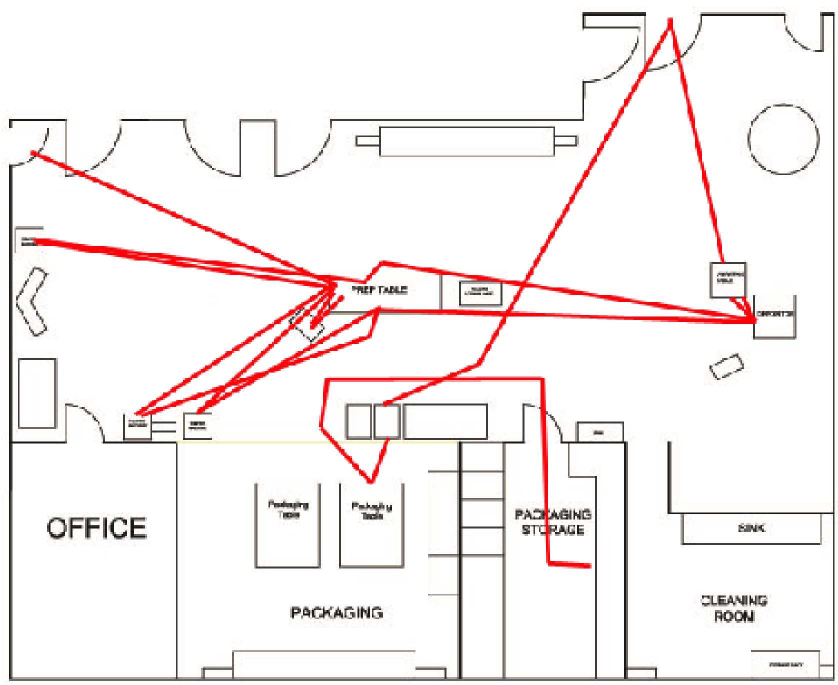


Figure 8: String diagram of the current flow in the chocolate bar making process.

the right temperature. Once the right temperature is met, the chocolate is transferred to the depositor which places the chocolate into molds. The chocolate is moved onto a vibrating table and then to a storage rack. The rack is rolled into the freezer located in the far right corner of Figure 8. After 15 minutes the rack is rolled across the facility to the packaging area. Finished goods are then moved to storage cabinets in the adjacent room. This whole process is represented by the red lines in Figure 8

The red lines show how much travel occurs during the production process. All the machines in the current layout are spread throughout the facility, causing greater distances between events. This leads to extra time spent on moving product, which can sometimes be heavy. From the temper machine to the depositor the distance is a little less than 36 feet and a worker must carry a thirty pound tub of warm chocolate. The current layout also has many overlapping paths that can cause unnecessary traffic in the production process.

We recorded the distances and times for each event in the chocolate bar making process. With the data collected we created a flow operations chart for the present facility, which is partially shown in Figure 9. The completed flow operation chart can be found in Appendix B.

Present Flow Operation

Location: Cal Poly Chocolates		**Summary**			
Activity: Chocolate Bar Making		**Event**	**Present**	**Proposed**	**Savings**
Date: 4/19/13		Operations	9		
Operator: Student	Analyst: Taylor and Jason	Transport	8		
Circle Appropriate Method and Type Method: Present Proposed Type: Worker Material Machine		Delay	0		
		Inspection	1		
		Storage	0		
		Time (min)	401.18		
Remarks:		Distance (ft)	135.2		
		Cost			
Event Descriptions	**Symbol**	**Time (min)**	**Dist (ft)**	**Method Recommendation**	
Transport Chocolate to prep tables	➡	1.25	17		
Pour and mix chocolate pieces for melting	●	3.2	0		
Transport to temperer	➡	0.48	8		
Temper Chocolate	●	165	0		
Stir chocolate	●	0.5	0		
Transport to depositor	➡	0.75	35.7		

Figure 9: Partial image of the flow operation chart for the current facility layout.

With this chart we were able to determine the total production time and distance traveled during the chocolate bar making process. We focused on the transport events that had the greatest distance or time. The longest distance traveled was from the temper machine to the depositor. In our proposed layout we considered the travel distances for the chocolate bar process.

Taking into consideration of the travel times we also had to consider the facility constraints. The constraints were the location of wall sockets and special hookups such as air or water. We came up with a proposed layout shown in Figure 10. This layout can also be found in Appendix B. This new design brought machines closer together but still allowed enough room to move throughout the facility. We placed all the temper machines along the same wall and equal distance from the prep table. They are also now closer to the depositor, which has been moved to a more central location. We placed the enrober behind the depositor so it can be closer to the air hookup. We kept the packaging area in the same place because machines could not be placed on the raised floor.

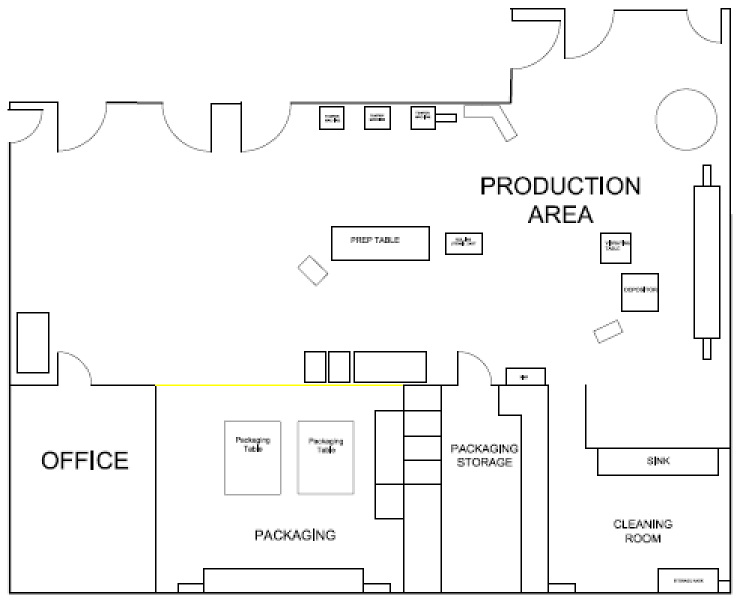


Figure 10: Proposed facility layout

We then created a string diagram for our proposed layout. This diagram is shown on the following page in Figure 11. The red lines are shorter and do not cross as often compared to the current layout. The distance between the temper machines and the depositor is now a lot shorter and a more direct route. To see the change in distances a flow operations chart was created for the proposed layout. The completed chart can be found in Appendix B, a small portion is shown in Figure 12. We were able to reduce the travel distances and the times associated with certain events. The last

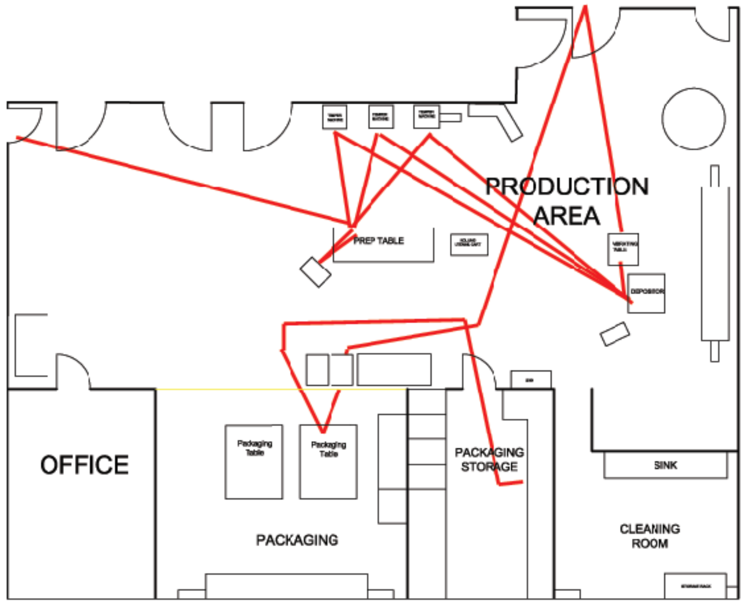


Figure 11: String diagram on proposed layout

Proposed Flow Operation

Location: Cal Poly Chocolates		Summary			
Activity: Chocolate Bar Making		**Event**	**Present**	**Proposed**	**Savings**
Date: 5/3/13		Operations	9	9	
Operator: Student	Analyst: Taylor and Jason	Transport	8	8	
Circle Appropriate Method and Type Method: Present Proposed Type: Worker Material Machine		Delay	0	0	
		Inspection	1	1	
		Storage	0	0	
		Time (min)	401.18	399.55	1.63
Remarks:		Distance (ft)	135.2	105.3	29.9
		Cost			
Event Descriptions	**Symbol**	**Time (min)**	**Dist (ft)**	**Method Recommendation**	
Transport Chocolate to prep tables	➡	1.25	17		
Pour and mix chocolate pieces for melting	●	3.2	0		
Transport to temperer	➡	0.07	4.5		
Temper Chocolate	●	165	0		
Stir chocolate	●	0.5	0		
Transport to depositor	➡	0.23	16.7		

Figure 12: Flow operation chart for proposed layout

layout shows the implementation of the flow wrapper that Cal Poly Chocolates is interesting in buying. The layout is shown in Figure 13 on the following page. We used our proposed layout and removed one of the packaging tables. The packaging table was replaced with the new flow wrapper. The installment of the machine did not affect the distance traveled during the process but it greatly reduced the process time. We created another flow operations chart to show the time saved with the new machine. This chart is partially shown below in Figure14. The full chart can be found in Appendix B.

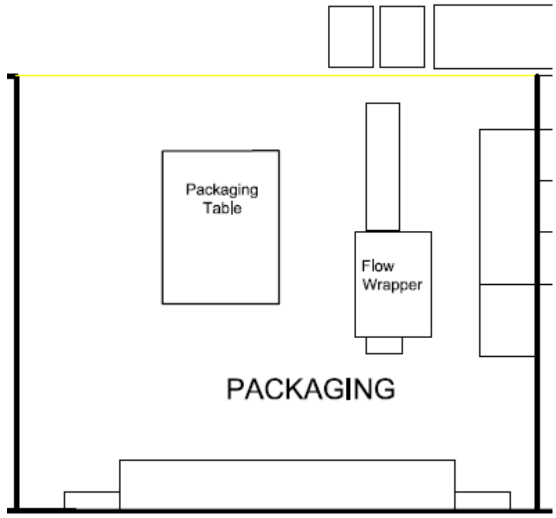


Figure 13: Implementation of flow wrapper into facility's packaging area.

Proposed Flow Operation

Location: Cal Poly Chocolates		**Summary**			
Activity: Chocolate Bar Making		**Event**	**Present**	**Proposed**	**Savings**
Date: 5/3/13		Operations	9	8	
Operator: Student	Analyst: Taylor and Jason	Transport	8	8	
Circle Appropriate Method and Type Method: Present Proposed Type: Worker Material Machine		Delay	0	0	
		Inspection	1	1	
		Storage	0	0	
		Time (min)	401.18	314.55	86.63
Remarks:		Distance (ft)	135.2	105.3	29.9
		Cost			
Event Descriptions	**Symbol**	**Time (min)**	**Dist (ft)**	**Method Recommendation**	
Transport Chocolate to prep tables	➡	1.25	17		
Pour and mix chocolate pieces for melting	●	3.2	0		
Transport to temperer	➡	0.07	4.5		
Temper Chocolate	●	165	0		
Stir chocolate	●	0.5	0		
Transport to depositor	➡	0.23	16.7		

Figure 14: Flow operation chart of the proposed layout with the addition of the flow wrapper.

Results

By creating flow operations charts for each facility change we were able to see the change in process time and distance traveled. From the current layout we had a process time of 401.18 minutes and a total travel distance of 135.2 feet. This time and distance is just for making chocolate bars. The values would be greater if we accounted for all products being produced that day. To cut travel distance we placed machines closer to each other in our proposed layout. With the new travel distances in the facility we were able to cut 1.63 minutes off the production time. The total distance was also cut by 29.9 feet. The last facility layout involved installing the packaging machine into the facility. With the installment of the packaging the distance traveled didn't change but the production time changed dramatically. The production time was reduced to 314.55 minutes. This is a savings of 86.63 minutes, almost an hour and a half of extra time.

Based on the data we can see that Cal Poly Chocolates layout is not efficient. We suggest moving machines closer together to shorten the transportation times. By placing machines closer together Cal Poly Chocolates will also create more open space in the facility. This will better prepare them for a future case where they may have to share the facility.

VI. Conclusion

In summary, this project began with gaining an understanding of the current process through research, observation of the process, conduction of time studies, and interviews with the managers. From here we were able to determine three main problems.

The First problem is that there is a large bottleneck in the packaging area in production. To solve this issue, we recommend Cal Poly Chocolates purchase a Flow Wrapper machine to increase their overall throughput. The second problem is that there is currently no reordering system in place. Implementing a two-bin system will provide structure to their inventory and hopefully eliminate any future stock outs. Lastly, the recent change in facilities has resulted in an inefficient layout. Adjusting to the proposed layout discussed earlier will reduce the production time and eliminate excessive travel time.

Once, implemented these improvements in Cal Poly Chocolates production process should produce the following results:

- Reduce daily production time by an hour
- No stock out costs
- Save 30ft in excess travel time daily

Although, the correct implementation of these recommendations will help to improve Cal Poly Chocolate's production process, there are still other areas that can be improved upon through additional projects. Some of these areas include marketing, work in process monitoring, improved database, quality control, and packaging fixtures.

REFERENCES

1) Lee, S. G., and S. W. Lye. "Design for Manual Packaging." *International Journal of Physical Distribution & Logistics Management* 33.1 (2003): 163-89. *ABI/INFORM Complete.* Web. 18 Feb. 2013.

2) Crowson, Richard *Assembly Processes: Finishing, Packaging, and Automation*. Abingdon :: CRC Press [Imprint], 2006

3) Morris, Scott. *Food and Package Engineering*. Hoboken: John Wiley & Sons, 2011.

4) Frank, P. (2008). Packaging solutions. *Baking Management, 12*(3), 30-30,32. Retrieved from http://ezproxy.lib.calpoly.edu/login?url=http://search.proquest.com/docview/220851625?accountid=10362

5) Anonymous, . "Robot Proves Best Feeder for Seasonal Chocolate." *Industrial Robot-an International Journal*, 32.1 (2005): 79.

6) Hillier, Frederick S., and Gerald J. Lieberman. *Introduction to Operations Research*. New York: McGraw-Hill Higher Education, 2010.

7) Levi, Retsef, Martin Pál, Robin O Roundy, and David B Shmoys. "Approximation Algorithms for Stochastic Inventory Control Models." *Mathematics of Operations Research*, 32.2 (2007): 284-302.

8) Karimi-Nasab, M, and I Konstantaras. "An Inventory Control Model with Stochastic Review Interval and Special Sale Offer."*European Journal of Operational Research*, 227.1 (2013): 81-87.

9) Arnold, J. R. Tony, Stephen N. Chapman, and Lloyd M. Clive. *Introduction to Materials Management*. Boston, MA: Prentice Hall, 2012.

10) Chaneski, Wayne S. "Back to Basics with the Simple Two-bin Reorder System."*Modern Machine Shop*, 75.4 (2002): 50

11) Waldrop, Rich. "Total Cost Analysis Aids Purchasing Negotiations." *Chemical Engineering* 119.1 (2012): 26-9. *ABI/INFORM Complete.* Web. 22 Feb. 2013.

12) Boardman, N. E. (2006). Cost-benefit analysis, concepts and practice. (3 ed.). Upper Saddle River, NJ: Prentice Hall

13) Shahanaghi, Kamran, et al. "Selecting the most Economic Project Under Uncertainty using Bootstrap Technique and Fuzzy Simulation." *Iranian Journal of Management Studies* 5.1 (2012): 9-24A. *ABI/INFORM Complete.* Web. 24 Feb. 2013.

14) Fuster, Gerard, Marta Schuhmacher, and José L. Domingo. "Cost-Benefit Analysis as a Tool for Decision Making in Environmental Projects." *Environmental science and pollution research international* 11.5 (2004): 307-12. *ABI/INFORM Complete.* Web. 24 Feb. 2013.

15) Anonymous, . "Robotics Ensure Sweet Swiss Precision." *Canadian Packaging*, 57.9 (2004): S1.

16) Wilson, Mike. "Developments in Robot Applications for Food Manufacturing."*Industrial Robot: An International Journal*, 37.6 (2010): 498-502.

17) "Related Garage, Storage Containers, Crates, Sterilite Products." *Http://www.justforoffices.com*. N.p., n.d. Web. 04 May 2013.

APPENDICES

Appendix A: Packaging

Cash flow and ROI Statement				
BENEFIT DRIVERS	**YEAR**			
	0	**1**	**2**	**3**
Greater margin driven by higher production capacity		**$14,500**	**$14,500**	**$14,500**
Improved cycle time benefits:				
Reduced labor cost due to less running time		**2,400**	**2,400**	**2,400**
Improved quality benefits:				
Fewer defects, resulting in less rework		**600**	**600**	**600**
Improved customer benefits				
New customer orders		**2,250**	**4,500**	**6,750**
Total annual benefits		*$19,750*	*$22,000*	*$24,250*
Implementation filter		**90%**	**95%**	**100%**
Total benefits realized		*$17,775*	*$20,900*	*$24,250*

Costs	Year 0	Year 1	Year 2	Year 3
Total	*$38,329*	*$0*	*$0*	*$0*

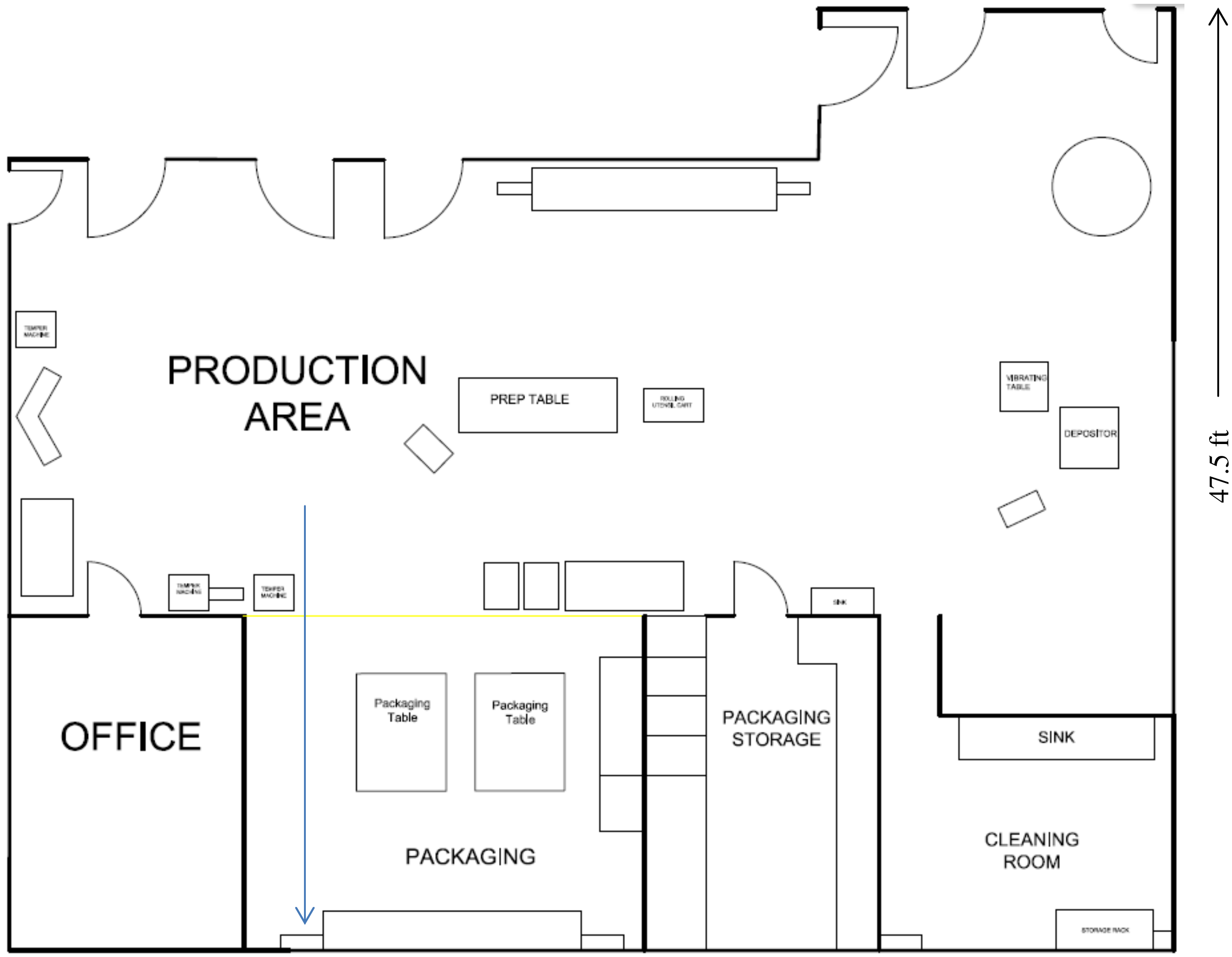
Benefits	Year 0	Year 1	Year 2	Year 3
Annual benefit flow	*($38,329)*	*$17,775*	*$20,900*	*$24,250*
Cumulative benefit flow	*(38,329)*	*(20,554)*	*346*	*24,596*

Initial investment	Year 0	Year 1	Year 2	Year 3
Initial investment	**$38,329**	**$0**	**$0**	**$0**
Total costs	*$38,329*	*$0*	*$0*	*$0*

ROI measures		Year 1	Year 2	Year 3
Net present value	*$8,875*			
Return on investment		*46%*	*55%*	*63%*
Payback (in years)	*1.98*			

Cash flow analysis for a packaging machine

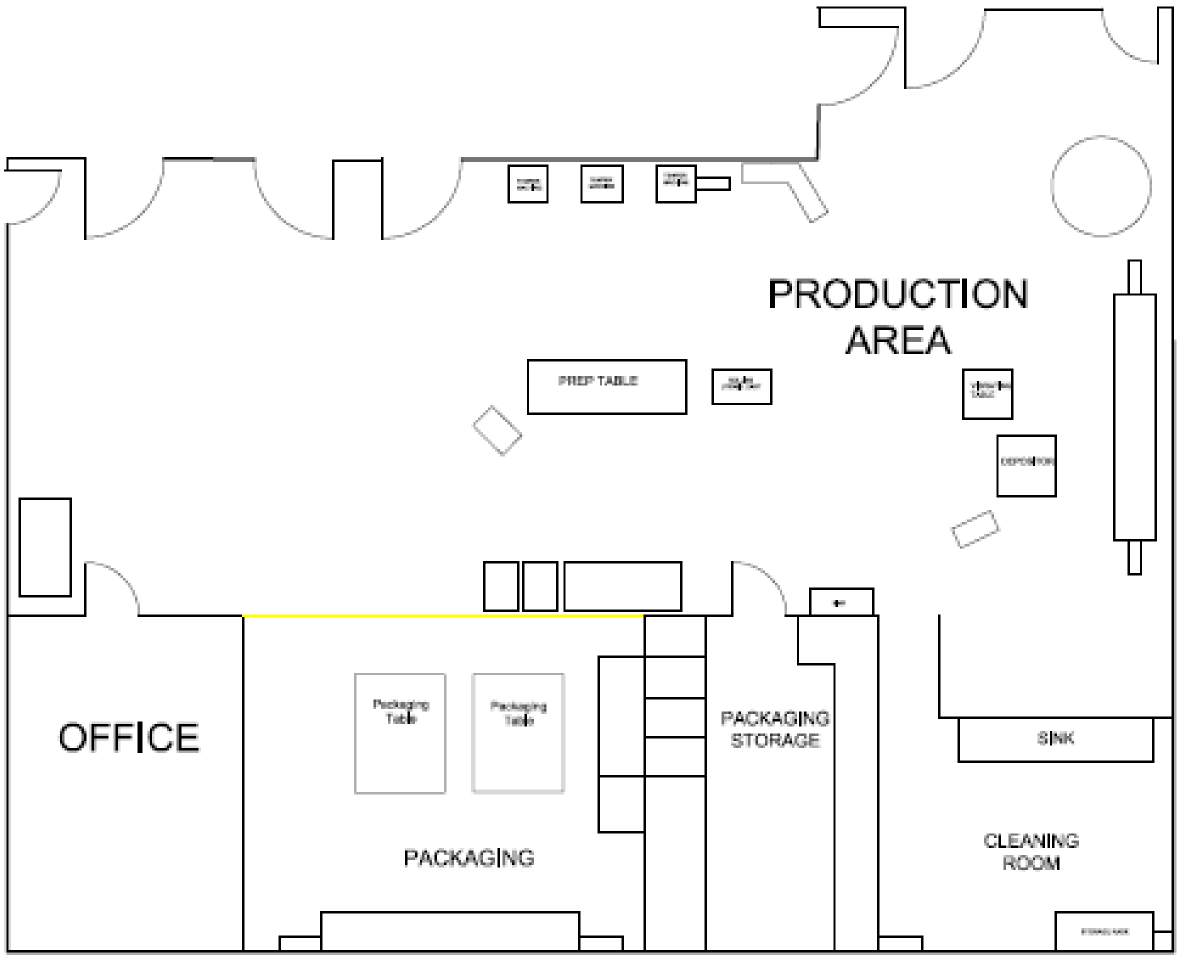
Appendix B: Facility Layouts



Present Flow Operation

Location: Cal Poly Chocolates		Summary			
Activity: Chocolate Bar Making		Event	Present	Proposed	Savings
Date: 4/19/13		Operations	9		
Operator: Student	Analyst: Taylor and Jason	Transport	8		
Circle Appropriate Method and Type Method: Present Proposed Type: Worker Material Machine		Delay	0		
		Inspection	1		
		Storage	0		
		Time (min)	401.18		
Remarks:		Distance (ft)	135.2		
		Cost			
Event Descriptions	**Symbol**	**Time (min)**	**Dist (ft)**	**Method Recommendation**	
Transport Chocolate to prep tables	➡	1.25	17		
Pour and mix chocolate pieces for melting	●	3.2	0		
Transport to temperer	➡	0.48	8		
Temper Chocolate	●	165	0		
Stir chocolate	●	0.5	0		
Transport to depositor	➡	0.75	35.7		
Run chocolate through depositor (180 times)	●	35	0		
Transport to vibrating table (180	➡	6	1		
Vibrate chocolate (180 times)	●	30	0		
Transport to rack (180 times)	➡	6	1		
Transport rack to freezer	➡	3	21		
Harden chocolate	●	15	0		
Transport chocolate to packaging	➡	3	32		
Remove chocolate from molds (180 times)	●	15	0		
Inspect chocolate (900 bars, 4 workers)	■	20	0		
Foil Wrap (900 bars, 4 workers)	●	70	0		
Glue label (900 bars, 4 workers)	●	25	0		
Transport to storage	➡	2	19.5		

Flow operation chart for the current facility layout.



Proposed facility layout

Proposed Flow Operation

Location: Cal Poly Chocolates		**Summary**			
Activity: Chocolate Bar Making		**Event**	**Present**	**Proposed**	**Savings**
Date: 5/3/13		Operations	9	9	
Operator: Student	Analyst: Taylor and Jason	Transport	8	8	
Circle Appropriate Method and Type Method: Present Proposed Type: Worker Material Machine		Delay	0	0	
		Inspection	1	1	
		Storage	0	0	
		Time (min)	401.18	399.55	1.63
Remarks:		Distance (ft)	135.2	105.3	29.9
		Cost			

Event Descriptions	**Symbol**	**Time (min)**	**Dist (ft)**	**Method Recommendatior**
Transport Chocolate to prep	➡	1.25	17	
Pour and mix chocolate pieces for melting	●	3.2	0	
Transport to temperer	➡	0.07	4.5	
Temper Chocolate	●	165	0	
Stir chocolate	●	0.5	0	
Transport to depositor	➡	0.23	16.7	
Run chocolate through depositor (180 times)	●	35	0	
Transport to vibrating table (180	➡	6	1	
Vibrate chocolate (180 times)	●	30	0	
Transport to rack (180 times)	➡	6	1	
Transport rack to freezer	➡	2.3	13.6	
Harden chocolate	●	15	0	
Transport chocolate to	➡	3	32	
Remove chocolate from molds (180 times)	●	15	0	
Inspect chocolate (900 bars, 4	■	20	0	
Foil Wrap (900 bars, 4 workers)	●	70	0	
Glue label (900 bars, 4 workers)	●	25	0	
Transport to storage	➡	2	19.5	

Flow operation chart for proposed layout

Proposed Flow Operation

Location: Cal Poly Chocolates		**Summary**			
Activity: Chocolate Bar Making		**Event**	**Present**	**Proposed**	**Savings**
Date: 5/3/13		Operations	9	8	
Operator: Student	Analyst: Taylor and Jason	Transport	8	8	
Circle Appropriate Method and Type Method: Present Proposed Type: Worker Material Machine		Delay	0	0	
		Inspection	1	1	
		Storage	0	0	
		Time (min)	401.18	314.55	86.63
Remarks:		Distance (ft)	135.2	105.3	29.9
		Cost			
Event Descriptions	**Symbol**	**Time (min)**	**Dist (ft)**	**Method Recommendation**	
Transport Chocolate to prep	➡	1.25	17		
Pour and mix chocolate pieces for melting	●	3.2	0		
Transport to temperer	➡	0.07	4.5		
Temper Chocolate	●	165	0		
Stir chocolate	●	0.5	0		
Transport to depositor	➡	0.23	16.7		
Run chocolate through depositor (180 times)	●	35	0		
Transport to vibrating table (180	➡	6	1		
Vibrate chocolate (180 times)	●	30	0		
Transport to rack (180 times)	➡	6	1		
Transport rack to freezer	➡	2.3	13.6		
Harden chocolate	●	15	0		
Transport chocolate to	➡	3	32		
Remove chocolate from molds (180 times)	●	15	0		
Inspect chocolate (900 bars, 4	■	20	0		
Machine Wrap (900 bars, 2 workers)	●	10	0		
Transport to storage	➡	2	19.5		

Flow operation chart of proposed layout with installment of packaging machine

Appendix C: Inventory analysis

MILK BARS		
Quantity	**Frequency/qtr**	**Buyer**
200	4	Campus Market
300	2	Cal Poly Bookstore
50	1	Village Market
100	2	Spencer's Market
15	2	Madonna Inn
15	1	Embassy Suits
Annual Demand	**5085**	

DARK BARS		
Quantity	**Frequency/qtr**	**Buyer**
200	4	Campus Market
300	2	Cal Poly Bookstore
50	1	Village Market
100	2	Spencer's Market
15	2	Madonna Inn
15	1	Embassy Suits
20	4	Botanical Gardens
Annual Demand	**5325**	

PEPPERMINT BARS		
Quantity	**Frequency/qtr**	**Buyer**
200	4	Campus Market
300	2	Cal Poly Bookstore
50	1	Village Market
50	2	Spencer's Market
15	2	Madonna Inn
15	1	Embassy Suits
Annual Demand	**4785**	

PEANUT BUTTER BARS		
Quantity	**Frequency/qtr**	**Buyer**
200	4	Campus Market
300	2	Cal Poly Bookstore
50	1	Village Market
50	2	Spencer's Market
15	2	Madonna Inn
15	1	Embassy Suits
Annual Demand	**4785**	

CASHEW CARAMELS		
Quantity	**Frequency/qtr**	**Buyer**
50	4	Campus Market
75	2	Cal Poly Bookstore
25	1	Village Market
Annual Demand	**1125**	

PEANUT BUTTER CUPS		
Quantity	**Frequency/qtr**	**Buyer**
50	4	Campus Market
75	2	Cal Poly Bookstore
25	1	Village Market
Annual Demand	**1125**	

S'MORES		
Quantity	**Frequency/qtr**	**Buyer**
50	4	Campus Market
100	2	Cal Poly Bookstore
50	1	Village Market
Annual Demand	**1350**	

MACADAMIA NUTS		
Quantity	**Frequency/qtr**	**Buyer**
36	4	Campus Market
75	2	Cal Poly Bookstore
Annual Demand	**882**	

Table 7: Chocolate Demand

Item	Units	Lead Time (weeks)	Minimum Order	Annual Demand	DDLT	Order Quantity	ROP	Notes
RAW MATERIALS								
Milk Chocolate	lbs	5	1 pallet (80 bags/pallet; 25lb/bag)	1405.67	234	1 pallet	12 bags	ROP
Dark Chocolate	lbs	5	1 pallet	1075.42	179	1 pallet	12 bags	ROP
Cashews	lbs	1	30 lb case	45.00	1.5	30 lb case		Eyeball
Macadamia Nuts	lbs	1	25 lb case	67.50	2.25	25 lb case		Eyeball
Peanut Flour	lbs	2	50 lbs	23.44	1.56	50 lbs		Eyeball
Powdered Sugar	lbs	1	50 lbs	22.50	0.75	50 lbs		Eyeball
Graham Crackers	ea	1	none	675.00	22.5	1 pk		32 per
Vanilla	qt	1	1 qt	2.81	0.09	1 qt		
Cal Poly 127	gal	3	1 barrel	0.35	0.04	1 barrel		eyeball
SG-3L Glaze	qt	3	3 gallons	0.18	0.02	3 gallons		eyeball
Marshmallow Fluff	lbs	1	1 case (18lbs)	11.9047619	0.4	1 case		eyeball
Crisped Rice	lbs	1	10 oz boz	15.95	0.53	10 oz boz		
Peppermint Oil	gal	1		0.00	0			eyeball
PACKAGING MATERIAL								
Boxes	ea	3	5000	2250.00	225	5000	300	ROP
Tins	ea	1	1000	562.50	18.8	1000	75	ROP, largest mac order
Inserts	ea	1	500	2250.00	75	500		2 bin
Foam	ea	1	1000	2250.00	75	1000		2 bin
Glue Sticks	bx	2	1 pack (30 sticks)	---	---	1 pack	5	ROP, max 5 workers use it
Staples	pk	2	1 box	---	---	1 box	250	ROP, largest smores orderX2
Milk Labels	pk	2	none	5085.00	339	600		2 bin
Dark Labels	pk	2	none	5325.00	355	600		2 bin
Peanut Butter Crunch Labels	pk	2	none	4785.00	319	600		2 bin
Peppermint Crunch Labels	pk	2	none	4785.00	319	600		2 bin
Cashew Caramel Label	ea	2	none	1125.00	75	100		2 bin
Peanut Butter Cup Label	ea	2	none	1125.00	75	100		2 bin
Smores Labels	pk	2	none	1350.00	90	100		2 bin
Mac Nut Labels	ea	2	none	562.50	37.5	100		2 bin
CP Sticker Sheets	ea	2	unknown	4162.50	278	400		2 bin
Foil	pk	2	1000 pieces	19980.00	1332	2000		2 bin
Gift Bags	ea	1	250	1350.00	45	250		2 bin
Shrink Bands	pk	1	1 pack (250 bands)	562.50	18.8	250		2 bin

Table 8: Total inventory with reorder quantities

MILK BARS				
Ingredient	**Unit of Measure**	**Quantity**	**Notes**	**Annual Demand**
Milk Bar (43g)	each	300		5085
Milk Label	each	300		5085
Foil	each	300		5085
Glue			too small	0
Cocoa Butter	scoops	4		67.8
Milk Chocolate	lbs	30		508.5

Table 5: Milk bar bill of materials

DARK BARS				
Ingredient	**Unit of Measure**	**Quantity**	**Notes**	**Annual Demand**
Dark Bar (43g)	each	300		5325
Dark Label	each	300		5325
Foil	each	300		5325
Glue			too small	0
Dark Chocolate	lbs	30		532.5

Table 9: Dark bar bill of materials

PEANUT BUTTER CRUNCH BARS				
Ingredient	Unit of Measure	Quantity	Notes	Annual Demand
Peanut Butter Crunch Bar (51g)	each	225		4785
Peanut Butter Crunch Label	each	225		4785
Foil	each	225		4785
Glue			too small	0
Milk Chocolate	lbs	25		531.6666667
Peanut Butter	lbs	1.25		26.58333333
Crisped Rice	lbs	0.75	Inspect first	15.95

Table 10: Peanut butter crunch bar bill of materials

PEPPERMINT CRUNCH BARS				
Ingredient	Unit of Measure	Quantity	Notes	Annual Demand
Peppermint Crunch Bar (51g)	each	225		4785
Peppermint Crunch Label	each	225		4785
Foil	each	225		4785
Glue			too small	0
Dark Chocolate	lbs	25		531.6666667
Peppermint Oil	tsp	5		106.3333333
Crisped Rice	lbs	0.75	Inspect first	15.95

Table 11: Peppermint crunch bar bill of materials

CASHEW CARAMELS				
Ingredient	Unit of Measure	Quantity	Notes	Annual Demand
Cashew Caramel (25g)	pk (8 per)	50		1125
Inserts	each	50		1125
Foam	each	50		1125
Cashew Caramel Label	each	50		1125
CP Sticker	each	50		1125
Box	each	50		1125
Milk Chocolate	lbs	7		157.5
Cashews	lbs	2		45
Dark Brown Sugar	lbs	4		90
Karo Syrup	lbs	4		90
Heavy Cream	lbs	4		90
Unsalted Butter	lbs	1		22.5
Tahitian Vanilla	cups	0.5		11.25

Table 12: Cashew caramels bill of materials

Butterscotch S'mores				
Ingredient	**Unit of Measure**	**Quantity**	**Notes**	**Annual Demand**
Butterscotch S'more (39g)	each	100		1350
S'mores Label	each	100		1350
CP Sticker	each	100		1350
Gift bag	each	100		1350
Staples	each	200		2700
Milk Chocolate	lbs	3		40.5
White Chocolate	lbs	0.5		6.75
Marshmallow Fluff	grams	400		5400
Graham Crackers	each	50	Squares	675
Brown Sugar	lbs	2		27
Heavy Cream	lbs	2		27

Table 13: Butterscotch s'mores bill of materials

MACADAMIA NUTS				
Ingredient	**Unit of Measure**	**Quantity**	**Notes**	**Annual Demand**
Macadamia Nuts (3oz)	pk	25		882
Macadamia Nuts Label	each	25		562.5
Tin Container	each	25		562.5
CP Sticker	each	25		562.5
Shrink Band	each	25		562.5
Milk Chocolate	lbs	0.5		11.25
Macadamia Nuts	lbs	3		67.5
Powdered Sugar	lbs	1		22.5
Dark Chocolate	lbs	0.5		11.25
Cal Poly 127	tbsp	4		90
Shellac Glaze	tbsp	0.5		11.25

Table 14: Macadamia nuts bill of materials

PEANUT BUTTER CUPS				
Ingredient	**Unit of Measure**	**Quantity**	**Notes**	**Annual Demand**
Peanut Butter Cups (18g)	pk (8 per)	36		1125
Peanut Butter Cups Label	each	36		1125
Inserts	each	36		1125
Foam	each	36		1125
CP Sticker	each	36		1125
Box	each	36		1125
Milk Chocolate	lbs	5		156.25
Peanuts	lbs	3.5		109.375
Peanut Flour	cups	0.75		23.4375
White Chocolate	lbs	2.25		70.3125

Table 15: Peanut butter cups bar bill of materials